

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: April 13, 1978

Project Title: Signal Analysis of Turbulence Study in Blood.

Project No: E-16-B02 (Continuation of E-16-B01) *Green Card*

Project Director: Dr. D. P. Giddens

Sponsor: DHEW, Public Health Service, National Institute of Health

Agreement Period: From 4/1/78 Until 3/31/79
(02 year only; overall grant period 4/1/77 - 3/31/79)

Type Agreement: Grant No. 5 R01 HL20835-02

Amount: \$37,327 (PHS - E-16-B02)
1,247 (GIT - E-16-326)
\$38,574 TOTAL

Reports Required: Terminal Progress Report

Sponsor Contact Person (s):

Technical Matters

Dr. Don Blount
Division of Heart and
Vascular Diseases
National Heart, Lung & Blood
Institute
National Institute of Health
Bethesda, Maryland 20014

Contractual Matters
(thru OCA)

Mr. Roger Deshaies
Grants Operation Branch
Division of Extramural Affairs
National Heart, Lung & Blood Institute
National Institute of Health
Bethesda, Maryland 20014

Defense Priority Rating: N/A

Assigned to: Aerospace Engineering (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director-EES
Accounting Office
Procurement Office
Security Coordinator (OCA)
Reports Coordinator (OCA)

Library, Technical Reports Section
EES Information Office
EES Reports & Procedures
Project File (OCA)
Project Code (GTRI)
Other _____

SPONSORED PROJECT TERMINATION SHEET

Date 3/25/82

Project Title: Signal Analysis of Turbulence Study in Blood

Project No: E-16-B02

Project Director: Dr. D. P. Giddens

Sponsor: DHEW, Public Health Service, National Institute of Health

Effective Termination Date: 12/31/79

Clearance of Accounting Charges: 12/31/79

Grant/Contract Closeout Actions Remaining:

None

- ☐ Final Invoice and Closing Documents
- ☐ Final Fiscal Report
- ☐ Final Report of Inventions
- ☐ Govt. Property Inventory & Related Certificate
- ☐ Classified Material Certificate
- ☐ Other _____

Assigned to: Aerospace Engineering (School/Laboratory)

COPIES TO:

Administrative Coordinator
Research Property Management
Accounting
Procurement/EES Supply Services

Research Security Services
Reports Coordinator (OCA) ✓
Legal Services (OCA)
Library

EES Public Relations (2)
Computer Input
Project File
Other _____

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

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GRANT APPLICATION

TYPE	PROGRAM	NUMBER
REVIEW GROUP		FORMERLY
COUNCIL (Month, Year)		DATE RECEIVED

TO BE COMPLETED BY PRINCIPAL INVESTIGATOR (Items 1 through 7 and 15A)

1. TITLE OF PROPOSAL (Do not exceed 53 typewriter spaces)

Signal Analysis of Turbulence Study in Blood

2. PRINCIPAL INVESTIGATOR

2A. NAME (Last, First, Initial)

GIDDENS, DON P.

2B. TITLE OF POSITION

Professor

2C. MAILING ADDRESS (Street, City, State, Zip Code)

Georgia Institute of Technology
Aerospace Engineering
Atlanta, Georgia 30332

3. DATES OF ENTIRE PROPOSED PROJECT PERIOD (This application

FROM

July 1, 1980

THROUGH

June 30, 1983

4. TOTAL DIRECT COSTS REQUESTED FOR PERIOD IN ITEM 3

\$233,416

5. DIRECT COSTS REQUESTED FOR FIRST 12-MONTH PERIOD

\$73,336

6. PERFORMANCE SITE(S) (See Instructions)

School of Aerospace Engineering
Georgia Institute of Technology
Atlanta, Georgia 30332
5th Congressional District

2D. DEGREE

Ph.D.

2E. SOCIAL SECURITY NO

256-50-6038

2F. TELEPHONE DATA

Area Code
404TELEPHONE NUMBER AND EXTENSION
894-3044 or 3001

2G. DEPARTMENT, SERVICE, LABORATORY OR EQUIVALENT (See Instructions)

School of Aerospace Engineering

2H. MAJOR SUBDIVISION (See Instructions)

College of Engineering

7. Research Involving Human Subjects (See Instructions)

A. ☒ NO B. ☐ YES Approved.C. ☐ YES - Pending Review

Date

8. Inventions (Renewal Applicants Only - See Instructions)

A. ☒ NO B. ☐ YES - Not previously reportedC. ☐ YES - Previously reported

TO BE COMPLETED BY RESPONSIBLE ADMINISTRATIVE AUTHORITY (Items 8 through 13 and 15B)

9. APPLICANT ORGANIZATION(S) (See Instructions)

Georgia Institute of Technology
225 North Avenue, N.W.
Atlanta, Georgia 30332
IRS Number 58-6002023
5th Congressional District

11. TYPE OF ORGANIZATION (Check applicable item)

☐ FEDERAL ☒ STATE ☐ LOCAL ☐ OTHER (Specify)

12. NAME, TITLE, ADDRESS, AND TELEPHONE NUMBER OF OFFICIAL IN BUSINESS OFFICE WHO SHOULD ALSO BE NOTIFIED IF AN AWARD IS MADE

Mr. Frank H. Huff

Comptroller

Georgia Institute of Technology

Atlanta, Georgia 30332

Telephone Number (404) 894-4622

10. NAME, TITLE, AND TELEPHONE NUMBER OF OFFICIAL(S) SIGNING FOR APPLICANT ORGANIZATION(S)

Dwight L. Allen

Deputy Director

Office of Contract Administration

Telephone Number (s) (404) 894-4819

13. IDENTIFY ORGANIZATIONAL COMPONENT TO RECEIVE CREDIT FOR INSTITUTIONAL GRANT PURPOSES (See Instructions)

20 - School of Aerospace Engineering

14. ENTITY NUMBER (Formerly PHS Account Number)

1586002023A1

15. CERTIFICATION AND ACCEPTANCE. We, the undersigned, certify that the statements herein are true and complete to the best of our knowledge and accept, as to any grant awarded, the obligation to comply with Public Health Service terms and conditions in effect at the time of the award.

SIGNATURES

(Signatures required on original copy only.
Use ink, "Per" signatures not acceptable)

A. SIGNATURE OF PERSON NAMED IN ITEM 2A

DATE

B. SIGNATURE(S) OF PERSON(S) NAMED IN ITEM 10

DATE

SECTION 1

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

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PROJECT NUMBER

RESEARCH OBJECTIVES

NAME AND ADDRESS OF APPLICANT ORGANIZATION

Georgia Institute of Technology, School of Aerospace Engineering, Atlanta, Ga. 30332

NAME, SOCIAL SECURITY NUMBER, OFFICIAL TITLE, AND DEPARTMENT OF ALL PROFESSIONAL PERSONNEL ENGAGED ON PROJECT, BEGINNING WITH PRINCIPAL INVESTIGATOR

D.P. Giddens, Ph.D.	J.I. Craig, Ph.D.	R.F. Mabon, M.D.	Vernon L. Newhouse
256-50-6038	409-70-4976	127-07-8113	150-28-8183
Professor	Associate Professor	Professor	Professor
Aerospace Engineering	Aerospace Engineering	Aerospace Engineering	Electrical Engineering

TITLE OF PROJECT

SIGNAL ANALYSIS OF TURBULENCE STUDY IN BLOOD

USE THIS SPACE TO ABSTRACT YOUR PROPOSED RESEARCH. OUTLINE OBJECTIVES AND METHODS. UNDERSCORE THE KEY WORDS (NOT TO EXCEED 10) IN YOUR ABSTRACT.

Previous research has shown that flow disturbances such as vortices and turbulence are created by mild constrictions in arteries. Accurate noninvasive detection of these disturbances could be of diagnostic value in the identification of mild atheromatous lesions. Although Doppler ultrasound devices which indicate blood velocity are commonplace, existing systems have severe shortcomings with regard to quantitative measurement of flows with a rapidly varying velocity such as encountered in turbulence; and there exists no established theory for defining the accuracy of turbulence measurement in blood. The present objectives are to establish such a theory, implement this theory via minicomputer signal processing of the Doppler signal, test the system by measurement in actual flows, and design an instrument which can operate in a clinical environment. The proposed theory, entitled the Digital First Moment (DFM) Method, was found to be accurate for synthesized Doppler signals under the previous grant period. The present proposal seeks to extend the work to actual flows, including blood flow in stenosed arteries. The methods of research include scattering studies which examine the effects of spectral broadening upon the first moment of the Doppler spectrum, methods for correcting for spectral broadening, theoretical estimates and experimental investigation of the limits of velocity fluctuation frequency response, comparisons of pulsed Doppler ultrasound velocity measurements using the DFM approach with laser Doppler anemometer methods, and a design study to define the requirements and accuracy of a clinical instrument which would be directed towards application to the carotid artery. Successful completion of the objectives would have several benefits: a comprehensive theory for time-varying velocity measurement with pulsed Doppler ultrasound would be available; a clinically useful instrument with well-defined accuracy would be designed for use in early detection of localized atherosclerosis of the carotid artery; and the methods developed would be available for other Doppler ultrasound applications such as volume flow rate measurement.

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FINAL PROGRESS REPORT

Grant Number: HL20835

Period Covered: 4/1/77 through 12/31/79

Investigator: D.P. Giddens, Ph.D.

Institution: Georgia Institute of Technology

Title: Signal Analysis of Turbulence Study in Blood

Accurate noninvasive detection of blood flow disturbances, such as vortices and turbulence, created by mild constrictions in arteries could be of significant value in the diagnosis of early stages of atherosclerosis. Although Doppler ultrasound devices which measure blood velocity are common place, existing systems have severe shortcomings with regard to quantitative measurement of flows with a rapidly varying velocity such as encountered in turbulence. The research under this grant examined two methods of treating a pulsed Doppler ultrasound signal to extract accurate turbulence information: a frequency tracking method and an evolutionary first moment method implemented on a digital computer. Significant improvements in pulsed Doppler ultrasound measurements were demonstrated with frequency tracking. Ultrasound measurements of turbulence under a wide range of flow conditions compared favorably with turbulence measurements with a laser Doppler anemometer in laboratory studies. The progress was sufficient to begin applying frequency tracking to ongoing research in poststenotic hemodynamics in animals and humans. The evolutionary first moment method involved development of a theory for utilizing power spectra of Doppler signals, sampled for a relatively short duration, to calculate the flow velocity rapidly as a function of time. The theory was then tested for accuracy on a variety of signals, ranging from signals with constant frequency to signals simulating the random frequency and amplitude of a Doppler signal arising from turbulent flow. Additionally, the effect of sampling windows on the analysis was studied. The first moment theory, as implemented on a digital computer, gave accuracy in accordance with design criteria in these studies. Actual Doppler signals, arising from real situations such as arterial blood flow, have yet to be studied by this evolutionary first moment method; and difficulties associated with accounting for acoustic properties of the insonation and scattering processes are expected. Considerable additional research is required to bring the first moment approach to its full potential. In summary, the research under this grant has yielded important improvements in the measurement of flow disturbances with ultrasound by using frequency tracking and has established a theoretical framework for digital first moment signal processing which has been proven accurate on simulated signals. The frequency tracking method is now being employed in animal and human studies related to atherosclerosis-induced flow disturbances.